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Modelling sub-hourly rainfall extremes with short records - a comparison of MEV, Simplified MEV and point process methods

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Accurate information on extreme rainfall frequency at sub-hourly timescales is useful for many hydrological applications, such as urban drainage design and stormwater management. However, the availability of sub-hourly rainfall records with sufficient length and quality is generally limited in most countries. With these short datasets, the conventional rainfall frequency analysis methods (e.g. annual maxima (AM) series) are prone to systematic biases and large uncertainties. In this work, we take advantage of long sub-hourly rainfall archives to explore the potential of alternative methods that exploit a larger fraction of the available data (or features), thus promising accurate estimates from relatively short data records.

The first method is based upon the Metastatistical Extreme Value (MEV) framework, which relaxes the asymptotic assumption of traditional AM methods. MEV considers, year by year, the full distribution of the underlying ordinary events and their number of occurrences. The second method, the Simplified MEV (SMEV, a variant of MEV), in which inter-annual variability is neglected in favour of simpler parametrisation and more robust parameter estimation, is also tested. So far, these two methods were shown to outperform traditional methods for daily amounts, but were never used on sub-hourly data.

The third method is based upon point process theory, which represents the temporal rainfall process in a realistic yet simple way, such that the hierarchical structure of rainfall is explicitly incorporated, and several parameters have a physical interpretation. Models based upon point process theory were known to be incapable of preserving extreme rainfall statistics at hourly and sub□hourly timescales. Nonetheless, a recent breakthrough has overcome this deficiency (Onof and Wang, 2019). In this work, a revised randomised Bartlett-Lewis rectangular pulse model (RBL) is employed.

Five-minute rainfall data from 5 long recording rain gauges in Germany – Bochum (69 years), Aplerbeck, Kruckel, Marten and Nettebach (49 years) – are used. The comparison is conducted by resembling the scenarios where sub-hourly rainfall time series data are available with various short lengths (i.e. 5/10/15/20 years). SMEV and RBL generally outperform the MEV and AM in

preserving sub-hourly rainfall extremes and are both much less sensitive to the use of short data records. SMEV outperforms RBL in preserving rainfall extremes at short return periods (< 10-year return periods), while they perform similarly at long return periods. RBL however has the advantage of preserving rainfall extremes across multiple timescales (i.e. from sub-hourly, hourly to 1-day) at the same time. The unsatisfactory performance of MEV is related to the influence of the low-intensity tail of yearly distributions.